Mathematical images in advertising: Constructing difference and shaping identity, in global consumer culture

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Mathematics educators have long emphasised the importance of attitudes and feelings towards mathematics, as crucial in motivating (or not) its learning and use, and as influenced in turn by its social images. This paper is about images of mathematics. Our search for advertisements containing such images of in UK daily newspapers, during 2006-2008, found that 4.7% of editions included a 'mathematical' advert, compared with 1.7% in pilot work for 1994-2003. The incidence varied across type of newspaper, being correlated with class and gender profiles of the readership. Three-quarters of advertisements were classified as containing only very simple mathematics. 'Semiotic-discursive' analysis of selected advertisements suggests that they draw on mathematics not to inform, but to connote qualities like precision, certainty and authority. We discuss the discourse on mathematics in advertising as 'quasi-pedagogic' discourse, and argue that its oversimplified forms, being empty of mathematical content, become powerful means for regulating and 'pedagogising' today's global consumers.

Keywords: mathematical images; press advertisements; discourse analysis; quasi-pedagogic discourse; popular culture; social class.

1 Introduction

Mathematics education researchers continue to be concerned about the disappointingly low levels of appreciation of, and success in, mathematics, among school and adult populations, and about their unequal distribution, in class and gender (and other) terms (e.g. Atweh, Graven, Secada, & Valero**,** 2011**)**. Many argue that students' affective orientations make important contributions to explaining these phenomena, and a wealth of research exists on the importance of students' attitudes and beliefs (e.g. Maas & Schloeglmann, 2009), emotions (e.g. Evans, Morgan & Tsatsaroni, 2006), and their 'relationships with mathematics' (e.g. Black, Mendick & Solomon, 2009).

National results in international assessment surveys (e.g. TIMSS, PISA) highlight the problem of under-achievement in mathematics in an intensified form. The linking of performance targets with comparative survey results also focuses the attention of policy-makers and researchers alike on schools' curriculum and assessment practices (Rizvi & Lingard, 2010).

Despite the latter's importance, these trends direct attention away from other sites where the public's image of mathematics may be formed or changed. Gail FitzSimons argues that *public images* of mathematics are 'created and reflected both in the cognitive and affective domain and concern[ing], *inter alia*, knowledge, values, beliefs, attitudes, and emotions' (2002, p. 43). She argues that the three key influences are: experiences in mathematics classrooms; expectations conveyed by parents and significant others; and stereotypes reinforced by media images. School and other cultural influences reinforce each other (pp. 43-45). Thus there are good reasons for

researching the production and circulation, as well as the reception, of images of mathematics in the wider culture.

Previous studies describe the relative 'invisibility' of mathematics in the public sphere (Noss, 1997; Coben, 2000), thus suggesting why students and adults may not recognise the value of mathematics, nor opt to study it. Yet 'numbers', increasingly accessible, including on the internet, are used widely to 'describe' and to assess reality in education, health, employment, business, sport, and other fields, especially within a performance-driven public sphere (e.g. Dorling & Simpson, 1998; Blastland & Dilnot, 2007). Within the culture generally, mathematics seems to be 'everywhere', including in film, works of art, and advertising. We return to this apparent paradox below.

Our project examines how mathematics as a subject and a way of thinking has been presented in various outlets of contemporary UK culture, outside official pedagogic discourse (Bernstein, 1990). It also explores how the availability and characteristics of different types of image of mathematics might have effects on people's attitudes and emotions towards mathematics (Mendick, 2007). In our pilot study (Evans, Tsatsaroni & Staub, 2007), we focussed especially on films and print advertisements as research objects especially suitable for discussion with international audiences of teachers and researchers: films, since globally circulated, are readily recalled by people of wide age ranges in many countries; print advertisements, compact and visual, can be appreciated by students and interviewees even if they haven't seen them before.

Our pilot research searched for adverts containing 'mathematical representations' in a number of editions of UK daily newspapers (sampled over 1994-2003). We calculated the *incidence*, the number of 'mathematical' adverts found, divided by the number of newspaper editions examined, as 1.7% (9 adverts found in 543 editions). With this small sample, we were unable to discern clear patterns of variation, for example across the different types of newspaper normally compared in UK analyses (Evans *et al.*, 2007). We therefore recognised the need to examine a larger, more representative, sample of newspapers.

In this main study, we confirmed our decision to focus on press advertisements as texts for analysis, for several reasons. Advertising in countries like the UK is a powerful, exceedingly well-resourced mode of communication. There is evidence that advertisements have 'an effect' on people's thinking and behaviour; for example, advertisements are seen as important 'cultural value carriers' which act as agents of cultural meaning transfer (Ciochetto, 2011; McCracken, 1986). Print advertising requires more cognitive involvement from the receiver than broadcast media. Several studies have demonstrated that press advertising requires 'high involvement' processing as compared to the 'low involvement' processing required for TV advertisements. This means that the receivers of the print advertising messages must use more conscious thinking when reading the adverts than when watching adverts on TV (Heath & Feldwick, 2007; Krugman, 1971). Thus, the print medium requires more 'engagement' than broadcast, as readers must choose material for attention; print advertisements provide more detailed information, with longer message lives. Within print media, newspapers have a broader target market than most magazines (Wells, Moriarty, & Burnett, 2006) and UK daily newspapers' readerships have relatively enduring social profiles, which allows for the study of advertisements targeted at distinct social groups.

We aim to investigate the discourse of mathematics in advertising. More specifically, we explore our central hypothesis that this discourse might turn mathematics, a specialised, powerful knowledge domain, into a set of techniques deployable particularly in the marketing of consumer goods and services. Sociologically, the reproduction of mathematics in the public sphere in this way, not as a system of specialised meanings to help in understanding the world, may raise issues

of social justice (Evans & Tsatsaroni, 2008). For those individuals and groups that have had less opportunity to acquire knowledge and appreciation of formal mathematics will tend to be more affected by such discursive constructions, being positioned as simple consumers of goods, rather than as mathematically literate individuals.

We adopt a discourse-theoretical approach, taking account of several developments: first, the visual aspects that are an essential component of most press advertisements, and are also paramount in today's culture (Rose, 2007; van Leeuwen & Jewitt, 2001); second, the functioning of advertising artefacts, both as commodities and as being about commodities (e.g. Williamson, 1978; Leiss, Kline & Jhally, 1990); and third, the location of advertising agencies and practitioners within the *field of symbolic control*, the field which uses discursive means to regulate social action. Though associated primarily with the state, this field is increasingly pervasive within the wider cultural field (Bernstein, 1990, 2001). Therefore, along with other discourse theorists drawing on Foucault's Power-Knowledge analysis (1977), we argue that cultural artefacts are powerful means for fixing meaning in dominant discourses, for constructing subject positions and for helping to form subjectivities, with implications for the exercise of power. Our contribution is to use Bernstein's idea of *quasi-pedagogic discourse* to conceptualise the problem and to produce a systematic discursive analysis.

This paper presents a quantitative analysis of the sample of 'mathematical' adverts found, and a discursive analysis of selected adverts, attempting to draw out the underlying discourses.

2 Mathematics in advertising: reviewing the literature

Although there is a wealth of research into cultural studies and media studies, much of it focused on advertising, there is very little research specifically addressing these areas from the viewpoint of mathematics and mathematics education. Two important exceptions are Peter Appelbaum's *Popular culture, educational discourse, and mathematics* (1995), and the work of Heather Mendick and colleagues (e.g. Mendick, 2007; Epstein, Mendick & Moreau, 2010).

Appelbaum explores how cultural representations of 'mathematics' generate normative concepts that foster or repress certain forms of educational practice. He also considers how these concepts and symbolic representations are constructed through ongoing mathematics education practice – mediated by the interaction of professional and public discourse (1995, pp. 4-6). He analyses documents and texts from the US in the 1980s and 1990s, including:

- academic and media coverage of mathematics teaching and learning, e.g. in his study of the creation of Jaime Escalante as the 'Best Teacher in America' and the film about him, *Stand and Deliver*
- responses to popular interest, or lack thereof, by mathematicians or educators, e.g. in subject association reports like NCTM (1989)
- popular films and prime-time TV about education and schooling, e.g. game shows involving chance.

Appelbaum and others distinguish between *mass culture*, created by interests with access to powerful media for distributing it, and *popular culture*, the way that audiences respond to, and possibly transform, the products of mass culture. The interrelation of these two forms is illustrated by the way that a pair of jeans can be transformed by tearing the fabric - in a way that expresses the identity of the wearer (Fiske, 1989). Thus, a pair of jeans can function both as a commodity and a cultural resource – as can mathematics (Appelbaum, 1995, pp. 186ff).

Appelbaum's theoretical analysis is comprehensive, and his focus on cultural representations is broad-ranging. However, the empirical material used is now somewhat dated, and focussed overwhelmingly on the USA (though, as argued in the introduction, references to mass-distributed films are globally recognisable). Heather Mendick and colleagues' more recent work in the UK (e.g. Mendick, 2007; Epstein et al., 2010) is concerned with reasons why students at school choose to engage (or not) with the study of mathematics. They aim to explore 'how popular cultural images of mathematics and mathematicians [influence] the relationships that learners form with the subject' (Mendick, 2007, p15). Here a person's 'relationship with mathematics' includes perceiving him/herself as 'good at it', liking it, deciding to continue studying it, and this forms part of their *identity*[1].

The researchers studied two groups of UK students: secondary students aged 15/16 (n=556) involved in deciding whether to continue or not with mathematics in their last two years of school, and undergraduates studying either mathematics or social sciences / humanities (n=100). Their data included (i) questionnaire responses; (ii) textual analyses of popular cultural texts considered as 'mathematical' by questionnaire respondents; (iii) results of focus group discussions; and (iv) individual interviews with subsamples of students.

At first sight, mathematics does indeed appear as rather 'invisible' in popular culture. Questionnaire respondents were asked to name up to two 'mathematical' texts, but 49% mentioned only one, and 25% could cite none. However, this did not signal an *absence*: 80 examples were cited by at least one respondent, and 22 by more than two – leading the researchers to conclude that mathematics was increasingly 'ubiquitous' in the public domain. These results depend of course on the perceptions of students responding to questionnaires as isolated individuals (i.e. prior to discussions in focus groups, or interactions with interviewers) – and the researchers allow that reading something as 'mathematical' depends on shifting ideas that are negotiable, and that depends on the context (Mendick, 2007, p18-19).

The empirical material for (ii) consists mostly of the documents designated as 'mathematical' most often by the students: websites, e.g. *BBC bitesize* (http://www.bbc.co.uk/bitesize/, offering revision resources for various English school exams); TV series, e.g. *Numb3rs*; films, e.g. *Good Will Hunting*, *A Beautiful Mind*, *Pi*; books, e.g. *The Curious Incident of Dog in the Night-time*; puzzles such as Sudoku[2]. The researchers interpreted these, plus what the students said in (iii) and (iv), to suggest several 'discourses of mathematics in popular culture representations', including mathematics as *mystifying*, *absolute*, *utilitarian*, *reductive* (i.e. techniques and number manipulation), *intellectual* and/or *aesthetic* (Mendick, 2007, p.18). They summarise the 'particular (and sometimes contradictory) meanings and discourses about mathematics that circulate in popular culture' as follows:

> … mathematics is represented as a secret language, mystical, even magical, difficult and

[1] Further, social difference is important, since 'students' relationships with maths are gendered, "classed" and "raced"'. This is supported, for example, by more positive responses from males to the question about being 'good at' (or 'very good at') mathematics (Mendick, 2007, pp21-22).

[2] Only one advertisement was mentioned, by one student: 'Get Rid of your Maths Gremlins and Get On', part of a campaign from around 2003, sponsored by the UK Office of Information to support the Skills for Life programme, aiming to encourage adults with literacy and mathematics difficulties to enrol on courses; see http://webarchive.nationalarchives.gov.uk/+/www.direct.gov.uk/en/educationandlearning/adultlearning/improvingyourskills/dg_065155

> aesthetically satisfying to those (few) who understand it, while mathematicians are often mad, or at least eccentric and different, mostly male and almost invariably white. (Epstein et al., 2010, pp. 45 & 47).

The team was especially interested in 'the ways the [students] deploy [these discourses] and negotiate their way through them' (p.46), and the ways in which young people position themselves in response to these discourses in choosing either to continue with mathematics or not, and in thinking of themselves as mathematical or not. The researchers go on to interpret what their interviewees say as

> both directly refer[ring] to and us[ing] images of mathematicians drawn from popular culture […]. This was also apparent in their discussions about their relationships to mathematics as a subject. For the most part, they took care to ensure that we knew that they knew they were drawing on stereotyped images - which did not stop them from finding these the first that came to their heads. Indeed, it would be surprising if these were not the first images that came to them, given their pervasiveness in popular culture. In other words, regardless of whether they have continued with mathematics or not, young people are aware of and embedded in notions of mathematicians as socially inept, obsessional, and definitely rather different from most people. The fact that they themselves identified their images as clichéd and stereotyped did not enable them to develop other, different images [with a few exceptions]. (Epstein et al., 2010, pp. 54-5)

The researchers also found that 'the influence of popular cultural representations on learners is diffusive and rarely directly acknowledged': only 4% of the GCSE students reported that popular culture had affected their decision to continue studying maths. However, the researchers also found the students 'simultaneously aware of a generalised presence of mathematics within popular culture'. And these 'influences from popular culture interact with influences from teachers, peers, and family members in complex ways' (2007, pp19-20), echoing the quote from FitzSimons (2002) above.

It is important to assess the claims made in this research. While we tend to agree broadly with Mendick and her colleagues that images of mathematics and mathematicians are increasingly 'simultaneously invisible and ubiquitous' (Mendick, 2007, p.18), we would also argue that this conclusion depends on assuming a reasonably shared understanding among researchers and questionnaire respondents as to what an instance of a 'mathematical' image might be – the difficulties of which assumption the researchers have correctly warned against (see above). Our view is that to talk about ubiquitous presence and at the same time invisibility calls for systematic empirical study to explore this apparent paradox. One of the aims of our analysis here is to do this.

More specifically, Mendick and colleagues aimed to explore how students respond to stereotypes circulating in popular culture. Questions such as how the kinds of mathematical ideas / resources recruited in popular culture (and indeed in different media) might work within such texts are not foregrounded by their work[3]. There is a need to find ways to analyse the structuring of discourse on mathematics within such domains of practice that go beyond the identification of stereotypical descriptions and related images and can show *how mathematical resources are put to work in particular texts, what subject positions become available within such discourses in relation to mathematics*, and what such discourses might mean to mathematics as a discipline. Such an analysis would address the space between the broad-brush, but (nevertheless) contestable descriptions of

[3] Advertising is an activity that throws up such questions especially clearly.

mathematics which the researchers have constructed, and the 'authentic' but partial (and not necessarily mutually commensurable) perceptions of the students.

There is also a question about the assumption of the effectivity of the mathematical images that Mendick et al. correctly wanted to explore – though they do this by focusing only on the reception site of such images. Concerning the way media discourses, particularly in advertising, influence the public's images of mathematics, Hall (1980) warns that the causality is not mechanical or straightforward. However, other researchers have addressed this question. For Williamson (1978), advertisements are powerful because, through their visual and verbal organisation and connotations, they produce particular ways of seeing. Advertisements in general function by creating a 'lack' or a 'need' (p.8) – and then by attempting to transfer visual and textual signifieds into their products, and by positioning viewers in an imaginary social space, where their needs will be met by the product. Advertisements refer outside of themselves, drawing meanings from one or more *referent systems*. Referent systems may range from the ideas of 'French *chic*' represented by a photograph of Catherine Deneuve in a women's perfume advert, to high-status knowledges such as mathematics, science and contemporary technologies. Even ideas whose actual content is hostile to advertising can function as referents; their content is neutralised or replaced. Such analysis is centrally concerned with the construction of social difference through signs, and with showing how meanings in the image are related to broader, dominant codes that encourage the viewer to produce preferred readings (Hall, 1980; Rose, 2007). Thus adverts both *reflect* and *elaborate* meanings around the position of mathematics in society and in people's consciousness.

3 Mathematics in advertising: a semiotic / discursive approach

Despite different theoretical assumptions between semiological and discourse analytic approaches, both centre on how texts and images construct specific views of the social world, and on the discursive positions of difference and authority articulated through them. But discursive approaches also attend to the social production and effects of discourse. A central idea is that 'the efficacy of discourse often resides in the assumptions it makes about what is true, real or natural, in the contradictions that allow it interpretive flexibility, and in what is not said...' (Rose, 2007, p165).

Discursive approaches understand images and texts as embedded in institutional practices (Rose, 2007). This implies that we must attend to the 'context of production', the institutional and other social contexts, imperatives and constraints, in which authors of texts work (Lister & Wells, 2001). For example, a cigarette advertisement is the result of complex interactions among the profit-making demands of capitalist economics; the restrictions imposed, e.g. by anti-smoking campaigners, health professionals and the law; the division of labour and organisational processes at any specific advertising agency; and the semiotic practices of advertising 'creatives'. Advertising agencies, therefore, tend to be subtle in their regulative effects.

Lister & Wells propose that we should also analyse the 'context of viewing' and the visual image 'in itself'. The former relates to the physical or social space where the image is located, which affects the way viewers encounter it. The latter refers to the properties of the image considered apart from individual acts of looking at it, namely its 'form and meaning' (2001, p70). The viewing position, as a 'subject position', is not ideologically neutral: images may place us in a privileged position; they also give us an identity, albeit a transient one, consequent upon looking at the image and engaging with it. Finally, in showing the 'complexly coded' (p89) nature of cultural artefacts, Lister & Wells acknowledge a methodological eclecticism, which they nevertheless perceive as a strength – since the analyst can attend to the many moments within the cycle of production,

circulation and consumption of the image through which 'meanings accumulate, slip and shift' (p90), while taking account of political issues, institutions and ideological discourses.

Basil Bernstein (1990, 2000) was concerned with tracing the grounding of social practice within relations of power, social class relations in particular. His focus on language was motivated by interest in how symbolic structures relate to social structures and processes. Concerning the construction of discourse, his sociological theory provides the key concept of *recontextualisation*. Predominantly applied to formal education, this refers to ways that *pedagogic discourse* is created through social processes of selection, repositioning and refocusing of elements drawn from knowledge producing discourses (Bernstein, 1990). Crucial is his conception of pedagogic discourse as '*a principle for appropriating other discourses and bringing them into a special relation with each other for the purposes of their selective transmission and acquisition*' (p183; emphasis in the original). Such processes entail transformations of elements and changes in social relations[4]. Moreover, like official pedagogic discourses, media discourses play a major role in regulating the (re)construction of identities and subjectivities. Agencies of the field of symbolic control are 'concerned with the regulation of social relationships, consciousness, disposition and desire' (Bernstein, 2001, p21). Symbolic control is 'the means whereby consciousness is […] distributed through forms of communication which relay a given distribution of power and dominant cultural categories…' (Bernstein, 1990, p.134).

In this theory, pedagogic discourse assumes priority over other 'unofficial' or non-state discourses in the cultural field. However, a poststructuralist reflection on Bernstein's notion of discourse (Delamont & Atkinson, 2007) recommends greater consideration of interconnections between the wider cultural field and the field of education; or, more precisely, of the perpetual reconstitution of their respective boundaries through the influence of internal and external forces. This supports the idea of using Bernstein's main concepts in analysing other discourses such as those produced by advertising agencies.

Further, Bernstein's analysis of pedagogic discourse provides insights relevant to the construction of a discursive approach to advertising. We can consider *cultural productions*, whether oral communications in the classroom, textbooks, syllabuses, advertisements or films, as the means by which power relations translate into discourse and discourse into power (Bernstein, 1990) – through classification and framing. *Classification* refers to the strength of the boundaries between contents in the organisation of discourse (e.g., different school subjects; scientific vs. everyday knowledge); *framing* refers to the controls on communication (e.g. visible or invisible). Both concepts utilise the idea of the *boundary*, pointing to the importance of describing changes in its strength in the processes of recontextualisation through which (pedagogic) discourse is constructed, with class (gender or ethnic background) related effects in its acquisition. Other work on changes in pedagogic discourse and practices demonstrates the regulative consequences of the tendency to weaken boundaries between academic-esoteric and everyday-horizontal discourses (Bernstein, 2000) on institutions, professionals and students; in particular, that 'the emptying of disciplinary contents…creates the conditions for social regulation', by depriving students of intellectual resources for thinking and acting (Sarakinioti, Tsatsaroni & Stemelos, 2011, p. 84). Put differently, '[p]edagogic discourses can vary in the degree to which they impose a particular, normative framework upon social practices or create the possibilities for their critical questioning and reinterpretation' (Moore with Jones, 2007, p. 134). The degree to which the (scientific) content dimension of the pedagogic discourse relates to the regulative dimension, that is to say, the

[4] Chouliaraki & Fairclough (1999) propose that this conception of discourse can be extended to the discourse of television news or the discourse of advertising.

discourse regulating social relations and expectations about 'contact, character and manner' (Bernstein, 2000, p13) is consequent upon the principles (classification and framing) used in the structuring of a particular discourse.

Unlike pedagogic discourses that form more durable pedagogical relations and communications, media and other cultural representations contain a range of discourses that are organised segmentally (rather than 'vertically'), and aim to maintain, develop or change an audience niche (Bernstein, 2000). This segmental organisation means one cannot expect a strong, or even indirect, control over the context, social relations and motivations of the receivers / consumers of media discourses. Bernstein calls such cultural forms *quasi-pedagogic discourses*, since they entail some form of social regulation, irrespective of how messages are acquired by particular individuals[5].

This perspective indicates that study of the mathematical identities created during formal schooling would benefit from empirical work on pedagogically relevant discourses and practices in the increasingly complex field of cultural (re)production. Audio-visual broadcast products, films, advertisements, and internet webpages and communications represent an important and growing category of artefacts in contemporary capitalist societies, characterised by an increased 'salience of discourse' within them (Chouliaraki & Fairclough, 1999, p. 10); that is, these 'cultural commodities' continually undergo a building up of discursive aspects which largely constitute them. Advertisements, in particular, are forms within mass communication, and a print advertisement has a potentially huge readership. In recent decades, scholarship on mass communication has focused on the reception of broadcasting and the press by audiences and readers, showing that a single text is open to diverse interpretations: 'People also establish their identities and their differences through the diverse ways in which they interpret texts, and more generally incorporate them into their own practices' (Chouliaraki & Fairclough, p. 14). Different interpretations entail bringing different discourses to the interpretation of a text, thus creating in a sense a new 'hybrid' text. Furthermore, while 'the homogenisation of the spread of advertising [and cultural commodities more generally] goes along with a heterogenisation of meaning[,]…interpretations do not vary without limit ...' (p. 15). This suggests that, in order to interpret an advertisement, we need to look at it within the concrete discursive practices in which it is used. At the same time, the spread through contemporary societies of homogenised discourses limits the possibilities of individual responses. So we argue that analysing the discourse created in advertising texts, itself a 'hybrid' – that is, a recontextualisation and re-articulation of other discourses – is a crucial aspect of research on social practices (Chouliaraki & Fairclough, p. 16). Indeed, Bernstein's idea of the importance of recontextualisations (initially) done by agencies in various domains of the cultural field gives support to our claim that it is necessary (though not sufficient) to analyse the discourse of advertising *per se* – rather than moving immediately to assess audience responses.

Thus, our overall project starts from the idea that cultural representations, such as advertisements, play a major role in reinforcing (or challenging) long-term public images of mathematics, thereby reproducing (or disturbing) dominant social discourses and knowledge discourses (i.e. school subjects, disciplines) and positioning subjects in certain ways. In particular, our hypothesis is that the modes of communication (strong / weak classification and framing values) created by advertising texts work to differentially distribute forms of consciousness, identity and desire.

Our discussion of visibility, and of images of mathematics, discourses, and positioning, leads us to formulate three broad research questions:

[5] This terminology receives support from Leiss et al. (1990) who suggest the possibility of consumers being 'educated' over time in how to read adverts, through changing forms and strategies of advertising.

Research Question 1 (RQ1): How 'visible' is mathematics in UK press advertising; that is, how much do newspaper advertisements use representations of mathematics as a resource to construct their messages? Are there differences among newspapers, related to differences in social class or gender composition of their readerships?

Research Question 2 (RQ2): What kinds of representations of mathematics can be identified in our sample? How is the discourse of mathematics constructed in this context?

Research Question 3 (RQ3): In what ways are readers/consumers positioned by discourses on mathematics, for example as knowledgeable and able to use their knowledge? How may this vary according to social class and gender?

These Research Questions implicitly distinguish 'images of mathematics', where the focus is at the level of discursive construction and discourse (themselves drawing on multiple non-mathematical discourses), from 'representations of mathematics', which appear as overt features of the texts considered, and are in turn used to construct images of mathematics.

4 Methodology

In order to address our Research Questions, we began by mapping the incidence and characteristics of mathematical representations in our chosen cultural domain of press advertisements (see Introduction). Since each UK national newspaper publishes some 100 pages daily, including an estimated 30 to 75 adverts (excluding classifieds), sampling of newspaper titles and of time periods was necessary. Newspaper readership profiles based on social class ('social grade')[6], gender and age are provided by the National Readership Survey (NRS, 2006-07), and are used by advertisers to describe British newspapers. We focus on social class and gender profiles here.

British newspapers are traditionally grouped into three categories: broadsheets (or 'qualities'); 'mid-market' tabloids; and mass market 'popular' tabloids (Cridland, 2009). The three groups differ in their styles of presentation, reporting and commentary – and in their readership profiles; see the noticeably different percentages of ABC1 readers for the three groups in Table 2. We sampled:

- four of the five 'quality' papers (*Daily Telegraph*, *Financial Times*, *The Guardian*, *The Times*)
- two mid-market papers (*Daily Express*, *Daily Mail*)
- three 'popular' papers (*Daily Mirror*, *Daily Star*, *The Sun*).

We selected two three-month time periods, Sept. - Nov. 2006, and Jan. - March 2008: this generated between 150 and 185 editions including Sunday editions (where appropriate), for each paper. For *The Guardian* and its Sunday paper *The Observer*, we also examined some 90 additional editions from an intermediate period (July - Sept. 2007)[7].

[6] The social grades (A, B, C1, C2, D, E) are based on the occupation of the main earner of the family. For example, social grade A includes higher managerial, administrative and professional roles; social grade E includes casual and lowest grade workers, and state benefit claimants / pensioners only. We follow standard practice of using two main categories: ABC1 and C2DE (Newspaper Marketing Agency, 2012). The ABC1 category includes higher roles (as for grade A above), intermediate roles, and junior roles (e.g. administrators). The C2DE category includes skilled working class, semi-skilled and unskilled manual workers, and others (as in category E above).

[7] These editions were readily available, so we used them to enhance our dataset. Before integrating them into the rest of the sample, we checked that their inclusion did not appreciably change the overall incidence of mathematical adverts observed, either for quality papers, or for *The Guardian* itself.

With our sample specified, we 'screened' every advert in some 1600 editions of the selected newspapers for instances of what were to us *prima facie* 'mathematical' representations. To do this, we used a broad, pragmatic characterisation of mathematics as a discursive form in which the texts include signifiers which are readily recognisable, e.g. symbols, graphs, equations. In the coding, we worked to ensure that our categorisations were *reliable*, as follows. First, we aimed to adopt a consistent categorisation of adverts according to whether they included elements that would be seen as 'mathematical' in public discourses of mathematics[8]. Next we set down clear rules for categories, building on those from the pilot study. And we discussed each advert considered by one team member as 'definitely including a mathematical image' – or 'borderline' – with another member, to maintain reliable criteria.

As indicators of a 'representation of mathematics', we included signifiers, images or symbols which we recognised as 'mathematical' (in the sense above), for example, one (or more) of the following:

- 'keywords' (naming the field or part of it), for example, *mathematics, mathematician(s), geometry, algebra, number(s), calculation(s), sums, percentage(s), equation(s), statistics*
- name or picture of a prominent mathematician/scientist, such as Einstein or Thales (Evans *et al.*, 2007)
- mathematical expression, equation, or formula
- graph or chart.

We cast our net widely to include all potentially interesting cases, but *excluded adverts that merely quoted numbers, prices or discounts*[9]. Of course, a number of adverts that survived the initial screening, coded as '*prima facie* mathematical' and thus included in the sample, turned out, after further analysis, to be only tenuously mathematical.

We coded the adverts, following standard procedures of quantitative content analysis (e.g. Bell, 2001). In the process, we added a new category of *type of mathematical content*, 'configuration of numbers, measurements or mathematical symbols', and we separated the (unexpectedly frequent) use of *squares and powers* from other *mathematical expressions*. We also categorised the *complexity of mathematical content* in each image as 'simple' or 'more advanced' (see examples in next section), and coded the *product group* advertised. Repeat appearances in different newspapers of the same advert were noted.

The methods used for selecting and analysing the adverts from a discourse analytic perspective are described in Section 6.

5 Results for the overall sample

RQ1 considers the visibility of advertisements containing mathematical representations, and differences among the selected newspapers depending on the social class and gender composition of their readerships.

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[8] We took special care to use this scheme consistently, since we were mindful that reading something as 'mathematical' or not is negotiable and context-sensitive (see Section 2 above).

[9] As illustration, two adverts initially considered 'borderline', but ultimately excluded, were: 'You're our Number One'(strapline), plus a numeral '1' (graphic) (RX1, *Daily Mail*, 25.11.06); and 'We donated 5% of the purchase price of school uniforms you bought […], adding up to a massive £645,000' (copy) (RX8, *Guardian*, 9.10.07).

Table 1 ABOUT HERE

In Table 1, we see that the *incidence* (number of adverts found, divided by number of editions), at 4.7% overall, is about three times as high as in the pilot, 1.7%. This increase may be due partly to the larger, more representative corpus examined (1609 editions of nine newspapers), but it also suggests a greater use of adverts containing mathematical images during 2006 - 2008, compared with 1994-2003.

For the relationship between the social class and gender profiles of the readership of newspapers, and the incidence of 'mathematical' adverts, see Table 2.

Table 2 ABOUT HERE

Table 2 shows a clear stratification of the nine newspapers into three familiar types – 'quality', mid-market and 'popular' papers – according to the percentage of ABC1 or broadly 'middle-class' readers. And there is an apparent correlation between newspaper type / social class of readership and 'incidence' of mathematical images (see also Table 3).

There does not appear to be such a strong relationship between gender of readership and 'incidence': the two newspapers with the highest proportion of male readers, the *Financial Times (FT)* and the *Daily Star*, have very different incidences. But the scatterplot of incidence and percentage of male readers shows that the *Daily Star*, an 'outlier', falls outside the overall pattern, where the higher the percentage of male readers, the higher the incidence of mathematical adverts; see Figure 1.

Figure 1 about here

We can confirm the above impressions about the relationships between incidence of 'mathematical adverts' and newspapers' readership profiles, by using correlation coefficients. The correlation of incidence and percentage of ABC1 readers is large and positive, 0.862 ($p \leq .001$, highly significant statistically), showing a strong relationship between social class of readership and incidence of mathematical adverts. But for gender, the correlation of incidence and percentage of male readers is 0.493 ($p \leq .089$, not quite statistically significant at the 5% level). However, when we control for percent ABC1 readers, the partial correlation of incidence with percent male readers becomes large and positive, 0.850 ($p \leq .008$, highly significant). We can conclude that both percent ABC1 readers and percent male readers make *independent* contributions to 'explaining' (in the statistical sense[10]) a newspaper's incidence of adverts containing mathematical images.

Table 3 shows the results when we group the papers into the three types of newspaper. It clearly confirms the association between incidence of 'mathematical adverts' and social class of readership.

Table 3 ABOUT HERE

[10] Terms like 'correlation' and 'statistical explanation' do not of course indicate *causation*, i.e. that the differing aggregate social class (and gender) positions of the newspaper readerships *determine* the level of 'mathematical' adverts published. Asserting the latter would require additional information, for example about the perceptions and motivations of advertising agencies.

RQ2 considers the kinds of representations of mathematics that can be identified, and the ways that advertisements use mathematics as a resource to construct their messages. In Tables 4 and 5, we classify each of the adverts according to the main category of 'mathematical image' used in the advert. Since some of the 76 adverts found were 'repeats' (in different newspapers), we have only 56 (not 76) distinct adverts.

Table 4 about here

In Table 4, simple uses of keywords – such as 'Fundamental. Mathematical' (RB36, *FT*, Sept. 2006), and 'Do the maths!' (RB14, two qualities and one mid-market, Sept. 2006) – accounted for almost 15% of the types of mathematics used (8 adverts). Configurations of numbers, measurements, or mathematical symbols accounted for 12.5% more (7 adverts), together totalling one-quarter of the adverts found. The latter category included: an advert reporting simple results from the 2006 National Student Survey ('9 ½ / 10 for student satisfaction… No other university scored higher.') (RB3, *Daily Mail*, Sept. 2006); and an advert for financial services, where a face was constructed from numerals (RB34, *FT*, Jan. 2008).

Adverts using equations, formulae and mathematical expressions accounted for a further quarter of the sample (29% or 16 adverts). Most were categorised as 'simple' mathematically, with three classified as 'more advanced'; see Figures 2 and 3, respectively, and analysis in the next section.

Figure 2 and Figure 3 about here

Adverts using charts and graphs accounted for 30% (17 adverts): all but four presented fictitious data, often 'playfully'. Moreover, almost all could also be considered as 'simple' mathematically, with the exception of one advert for an asset management firm which uses a parabola in one graphic, Figure 4 (RB49, *Financial Times*, Mar. 2008); see also next section.

Figure 4 about here

Finally, we categorised the adverts using squares and powers (8 adverts, almost 15% of the sample), as arguably 'more advanced' mathematics. For example,

> Talented^2 … Discerning^2… Responsive^2 … Independent^2 … All the qualities you could hope to find in […] business advisers, now available to the power of two.
> (RB12, *Guardian*, July 2007)

Considering all 56 distinct adverts, we categorise around three quarters as using very simple mathematics. Given the strong social class stratification found across UK newspapers, we considered possible differences in the types of mathematics used in adverts in different newspapers, in terms of 'simple' or 'more advanced' mathematical images; see Table 5[11].

Table 5 about here

[11] When an advert appears in two 'types' of newspaper, we apportion its frequency 0.5 to each type in Table 5; see for example the analysis of advert RB2 (Figure 3) in the next section.

In Table 5, all but one of the adverts containing 'more advanced' mathematics were found exclusively in the quality papers; that advert was RB2 (Figure 3), which appeared in both *The Times* (a 'quality') and the *Daily Mail* (mid-market) in November 2006, and hence was allocated 0.5 to each newspaper type. In addition, all but one of the adverts using charts and graphs appeared in the qualities – whether simple or 'more advanced'. Thus, the quality papers have a wider range of types of mathematics used than the others, and a higher proportion of more demanding mathematics.

Of the 16 uses of 'equations' in the adverts found, most (13) might be more accurately called 'formulae', since they involve an 'input-output' relationship: the 'mathematical' expression on the left-hand side is set equal to what the reader 'needs' / needs to do, to attain an 'object of desire' on the right. Sometimes the elements to be summed are words, or a mixture of words and figures – e.g. '40min + £199 = YOUR PERFECT MORTGAGE' (RB35, Figure 2). Alternatively, the elements are combined in a 'more advanced' equation:

> [Your ambitions X Our abilities]^{QNB} = The Winning Formula
> (RB25, *Financial Times*, Sept.2006)

This 'equation' is not really meaningful in mathematical terms, since 'QNB', the name of the investment bank, is inserted where a quantitative exponent or power should be.

These formulae illustrate a quality of many of the representations of mathematics found: much of the 'mathematics' is 'fashioned' to give a desired impression about the product – but in the process it is emptied of meaningful mathematical content. Although 'equations' or formulae are used relatively frequently in the adverts found, they are rarely meaningful in mathematical terms – and hence they rarely position the reader as 'mathematically literate'.

RQ3 asks how readers/consumers are positioned by discourses depicting mathematics, and how this may vary according to social location (class and gender). The requisite analysis mostly needs to be done for particular cases (see next section). But since the social groups addressed by an advert relate to the type of products being advertised, we consider this aspect here. Each of the 56 distinct adverts was categorised by the product advertised; we took account of the product ostensibly being offered, and the group(s) of consumers addressed. Almost half (45%, or 25 adverts) were coded into two categories, 'Business finance & services' (e.g. Figure 4) and 'Personal finance' (e.g. Figure 2). The next most frequent category, 'Education & training' (16% or 9 adverts) includes six adverts for various types of management training, and two for educational toys and games, including Figure 3. These results suggest the importance of mathematics (and science) as referent systems – for financial services advertising in particular. For further discussion of the subsample of adverts for financial services, see Czarnecka & Evans (2013).

6 Analysis of selected advertisements and the discourse on mathematics

Here we describe the semiotic features of selected advertisements, i.e. each text 'in itself' (Lister & Wells, 2001). We selected these adverts to be representative of:

- the two most frequently found 'types of mathematics': 'equations or formulae' and 'graphs or charts', both 'simple' and 'more advanced'
- the three most frequently found product categories.

The latter range promised diversity in the construction of messages, related to addressees' social characteristics.

We thus selected advertisements for the following:
(a) mortgage brokers using a simple equation,
(b) an 'educational' toy, using a more advanced equation,
(c) asset management services, using a more advanced graph.
See Figures 2, 3 and 4 respectively.

6.1 A simple equation: 'Spend time relaxing ... not searching for a mortgage'

Figure 2 appeared in *The Times*, 3 Nov. 2006. In simple black and white, it promotes mortgage services. Under a photo of two pairs of feet sticking out of bed, a 'thought bubble' provides the strapline: 'Spend time relaxing ... not searching for a mortgage'. There follows a simple 'mathematical' equation or formula: '40min + £199 = Your Perfect Mortgage'.

The formula is meaningful in everyday discourse, but for the content to be 'mathematical', the same units need to be used for each term of the equation. Nevertheless, the equation, representing mathematics, stands for simple logic – and with the certainty of mathematics it promises success in achieving the desirable outcome. The word 'searching' in the strapline connotes difficulty, contrasted with 'relaxing' and links with the final promise: 'We'll find it'. The advert attempts to transform the reader's supposed search for a satisfactory mortgage into a technical problem which the service can solve. The words 'your perfect mortgage' assure consumers that their desires / fantasies will be met. Potentially difficult issues, such as whether the 'perfect mortgage' is affordable, can be left 'unsaid', in the dark of the advert's background (Rose, 2007, p165).

The crucial aspect of the 'mathematics' here is its simple logical form. The message is structured through a hybridised (weakly classified), but still recognisable, form of expression, but which lacks mathematical content. At the same time, the readers are positioned within the everyday world of action, but their 'common sense' is valorised through association with mathematics, indexed by the formula. The formula works as a regulative device, telling the reader what to do. The function of mathematics, recruited for its rationality, certainty and authority, is to induce the reader to follow the advert's injunction.

6.2 A 'more advanced' equation: 'Give him the Lift Off Rocket and who knows what he'll grow up to be'

Figure 3 appeared in *The Times* and the *Daily Mail*, in November 2006. It promotes Early Learning Centre (ELC) products, specifically the Lift Off Rocket, to stimulate children's cognitive development. The central photo shows a boy, playing with the Rocket, juxtaposed to his 'thought bubble' containing a complex equation, handwritten on graph paper, with several obvious scientific connotations. The equation purports to define V_e, presumably 'escape velocity', but the other symbols remain undefined. The strapline links the ELC toy(s) and the child's future: 'Give him the Lift Off Rocket and who knows what he'll grow up to be'. The visuals link the Rocket, representing stimulation of the child's development, and the equation representing the child's bright future.

At first, the advert appears simple: photo of boy with toy. However, the equation he imagines appears relatively complex in its mathematical form (cf. the simple equation in Figure 2). It

suggests a highly developed form of knowledge. This reinforces the brand's claim that its products support cognitive development. Besides the equation's mathematical form, its content is noteworthy. It is the only 'equation' we found that both appears potentially meaningful to mathematicians / physicists, and contains mathematical symbols possibly representing variable quantities, thereby suggesting stronger 'insulation' (classification) between mathematics and the everyday. But further investigation reveals the existence of much simpler formulae for escape velocity, derivable from Newton's Third Law. Thus the formula is likely imaginary, 'jazzed up' for the advert. Nonetheless, the advert positions readers, if not as knowledgeable about mathematical formulae, at least as able to recognise them as potential signifiers of high status 'scientific' domains, e.g. 'applied mathematics' or physics.

The advert addresses middle class readers (*The Times* and *Daily Mail*), who aspire to reproduce or improve their social position through their children's education. No matter whether they recognise the precise content of the mathematics in the formula – or whether they would critique its lack of meaning. The strapline, rich in meanings, supports the message. The second part, '...who knows what he'll grow up to be', captures, in its interrogative sense, the reader / parent's anxieties – and thus establishes the 'lack'/ need for the product (Williamson, 1978). It expresses, in its expansive declarative form, confidence in the child's bright future, represented by the complex equation. Thus, the product may lessen the parent's anxiety – and feelings of responsibility for the child's development. Furthermore, the use of 'and' to denote a simple consequence – 'Give him the Lift Off Rocket *and* he'll grow up to be what you aspire to' reassures the parent(s). Other inputs necessary for the child's success – besides toys they can afford (such as supportive teachers and learning environments) – are well in the background of this simple advert. Finally, we note that it is a *boy*, acting as an isolated individual, who, stimulated by the product, produces the equation.

In terms of structuring pedagogical principles, this advert recruits an apparently 'advanced' mathematical formula. This mathematical resource in its recontextualisation within the advertising text may be ambiguous as to whether it has mathematical content but its strongly classified linguistic expression and the strongly bounded scientific/mathematical domain to which it makes an appeal work to create and convey the message of the importance of mathematics in children's educational success and therefore the 'need' for the product. Within this discourse, the reader / parent is positioned as someone who (might) appreciate(s) mathematics and its scientific applications. At the same time, the discourse articulated reasserts dominant conceptions about mathematics that serve to reproduce both hierarchies of knowledge – mathematics assumed as the pinnacle, both intellectually and in supporting professional success – and also social hierarchies of class and gender.

6.3 A 'more advanced' graph: 'Innovative financial solutions'

Figure 4 appeared in the *Financial Times*, 3 March 2008, promoting asset management services. The photo shows a man wearing a suit, sitting on a sofa, looking under the cushions. The strapline 'INNOVATIVE FINANCIAL SOLUTIONS and their impact on performance' emphasises the company's potential. The parabola purports to present the relationship between the innovative qualities of investment 'solutions' and meeting investment objectives or 'performance'. The graph includes three 'data points': 'finding loose change' as low innovation and low performance, and 'finding customised investment solutions' as high on both variables – with 'finding "off-the-shelf" solutions' intermediate on both. The copy asserts the ineffectiveness of 'off-the-shelf solutions' and extols the values of Northern Trust's approach, since it 'helps deliver what matters most to clients' – because of the company's 'extensive pool of intellectual capital, research and technology'. The

text ends with a play on words: 'we'll leave no stone unturned … [but] your sofa cushions … remain undisturbed'. At the bottom, the qualities of the services offered are listed in the company slogan: 'Active, Quantitative & Manager of Managers'.

Mathematics is represented by a parabola, its importance reinforced by including 'Quantitative' among the company's valued qualities. The parabola is more 'advanced' mathematics than a straight line – although a straight line would have been mathematically adequate to represent the essentials of the relationship between innovation and performance, based on the three data points shown. Hence the advert aims for 'sophistication', with 'excess to spare'. It thus asserts the superiority of the customised investment solutions offered. The graph, representing mathematics, signifies the company's 'extensive pool' of expertise. This contrasts sharply with the 'realistic' photograph portraying the homely, perhaps slightly anxious, habit of looking for change under sofa cushions. Overall, the advert is reassuring: the company will find the 'solutions' for you (and your sofa cushions will remain undisturbed).

The advert appears to address corporate financial managers, or middle class individuals with ample funds to invest. It appeals to (*Financial Times*[12]) readers who are likely to recognise a parabola. By juxtaposing a visual image representing mathematics as a strongly classified, specialised field to a domestic world of habitual practices, the advertising text positions the subject not as somebody who is knowledgeable about, or likely to engage in, mathematical activity – reading the graph in detail – but as one who recognises in the graph the unequivocal expertise of this particular company; left on his own, he might revert to homely habits in managing his own finances. This is the 'gap' that the company proposes to fill. In the recontextualisation of mathematical elements, mathematical activity stands for scientificity and therefore expertise.

In particular, mathematics is used as a resource for meaning-making with words such as 'solution' (reverberating with 'problem-solution' couplets in mathematics) and 'quantitative'; and with the graph of the parabola. In the signifying chain of the advertising text potential mathematical signifieds are displaced, and the discourse is articulated around values associated with mathematical activity, here considered as high status knowledge and expertise. In this discourse, the reader is positioned as knowledgeable about mathematics to the extent that *he* (a typical *Financial Times* reader – see Table 2) can recognise, and identify with, not the specifics of mathematical reasoning, but the symbolisms which serve to transfer authority from mathematics to the company and its services (Williamson, 1978).

6.4 Summary of the Semiotic / Discursive Analyses

Here we summarise our semiotic/discursive analyses above of the three selected advertisements. The discourse articulated in these adverts recruits a variety of mathematical resources, but their recontextualisation entails their simplification and/or distortion, the displacing of any significant mathematical content and the superimposition of valued qualities associated with mathematics in common discourse, such as expertise and certainty. This is consistent with Williamson's (1978) view that advertisements appear generally to use science (and mathematics) as a Referent System. At the same time, our approach focuses attention on how signification and recontextualisation work in advertising practice, how discourses on mathematics are rearticulated within such practice, and what positions become available in this discourse for individual subjects.

[12] The *Financial Times* is a specialist daily newspaper, focussing on economic and financial matters.

The mathematical resources recruited function more through their form than their content. In the mortgage advert (Figure 2), a broadly 'positive' representation[13], the equation's simple form repeats, unchallenged, the dominant conceptions of mathematics as supremely logical, rational, certain, and effective. In the Rocket (Figure 3) and the parabola (Figure 4) adverts, signification is produced not only by the form but also by the content. However, the content does not function to enable mathematical processes that the reader could follow to make sense for him/herself. For instance, the parabola advert, emphasising choice and distinction, seems to appeal to those individuals from middle class strata who value customised solutions. This advert is relatively strongly classified in terms of mathematical content, producing specialised meanings, and strongly classified in terms of its linguistic mathematical form: it requires a certain 'competence' to read the graph (Lister & Wells, 2001, p72). However, the over-sophistication of the graphical form, and the naturalism implied in the realistic photograph (van Leeuwen, 2001), work powerfully to distract the reader from engaging with the mathematical content – but he can be reassured by the authority and expertise of the company who does the thinking for him. So we can say that the advertising practice, in its recontextualisation of the resources used and their reassembly (e.g. through photographic conventions) is appropriating the mathematical contents and setting them in motion 'under its own order' (Chouliaraki & Fairclough, 1999, p110). The mathematical forms and contents, connoting the high levels of power, intelligence and authority of mathematical representations – qualities which through the adverts are transferred to the company and its products – become potential means for regulating the actions and behaviours of individuals.

7 Discussion

Research Question 1 focuses on the 'visibility' of mathematics in UK press advertising. Our study suggests that this was on the increase in the period studied. We found an 'incidence' of adverts containing mathematical images of 4.7% of the editions examined, over two three-month periods during 2006-2008; this was higher than the 1.7% found in the pilot, for 1994-2003. There was a much higher incidence in 'quality' newspapers (8.2%, or 65 adverts in 790 editions) than in mid-market papers (2.3%) or 'popular' papers (0.6%). And for the nine newspaper titles, there was a strong correlation of incidence of 'mathematical adverts' with the percentage of ABC1 (middle class) readers, and also with percentage of male readers, controlling for social class. This unequal distribution of mathematical images across newspapers with socially differing readerships suggests that advertisers / agencies assume different levels of mathematical literacy or interest among readers of different newspapers.

Research Question 2 focuses on the kinds of representations identified. We classified three-quarters of the adverts in this extensive sample as containing simple, rather than 'more advanced', mathematics. These *simplistic* representations of mathematics include: all but one of the charts and graphs – with most using fictitious data or imaginary relationships – and more than three-quarters of the equations or formulae – with these generally lacking real mathematical content. The range of images was more restricted in the popular and mid-market papers, compared with quality papers. Thus, we might accept that mathematics still suffers from 'low visibility' – but this applies to different degrees for different social groups.

In terms of the discourse of mathematics constructed, we showed that advertisements use mathematics as a referent system to *associate* with the product, and transfer to it, valued characteristics of mathematics like precision, rationality and authority, rather than employing such characteristics to construct reasoned argument. In our analysis we focussed especially on the use of

[13] Unlike several adverts found in the pilot study; see Evans *et al*. (2007).

equations, or formulae. This mathematical form connotes qualities valuable for an advertisement's message: simplicity and certainty – it is 'logical'. Thus formulae are used to demonstrate how the 'left-hand side' of 'inputs', often including the product, *must* lead to satisfaction of need(s) indicated on the 'right-hand side'. The equation may also suggest a satisfying 'balance' between the two sides, a 'good deal'. Such claims work to link powerfully company/advert and consumers' values, suppressing mathematical reasoning *per se* and making it irrelevant to the addressee's decision-making.

The advertisements analysed in more depth in Section 6, and indeed in most of our sample, use mathematics as rhetorical means to persuade. They represent mathematics in simple forms, but in most cases with no mathematical content; however, there may be differences in how the mathematical form-content relationships operate, as each advert is made to appeal to different class strata, attracted by different values. We argue that these adverts tend to be 'weakly classified and strongly framed': they mainly function to control and to regulate (Bernstein, 1990, 2000). As explained in Section 3, framing refers to the question of who has control over the pedagogical process (e.g., selection of content, sequencing, evaluation, etc.), therefore of the structuring of the pedagogic relationship. As we saw in the semiotic analysis of the adverts, connotation is the linguistic process through which meanings referring to values are superimposed over any potentially meaningful mathematical content. Such meanings function as framing principles shaping the regulative dimension of the quasi-pedagogic discourse. Thus, in the imaginary discourse articulated in the advertising activity, mathematical thinking processes are rarely disclosed, and the language is rarely specialised.

With respect to Research Question 3, on the way readers are positioned by discourses in mathematics, the overwhelmingly *simplistic* representations of mathematics used, and the tendency to empty mathematical signifiers of meaningful mathematical content suggest a generally low level of mathematical demand made on readers by these adverts. Consequently, subjects are not offered the means to think for themselves. The emptying of disciplinary contents through connotation constructs strong framing in the quasi-pedagogic discourse, creating the conditions for social regulation. Our analysis shows that the idea of mathematics as a rational, authoritative and powerful form of knowledge is used to convey and transfer qualities that 'submit' the reader to the advertisers' control.

8 Conclusions and further research

In this paper, our fine-grained semiotic / discursive analysis allows us to identify positions available within the discourse being constructed, and hence to conjecture – but not to prejudge – the ways that individuals may possibly respond to the availability of these positions. This, we argue, is an important stage of research in analysing mathematics in advertising, and other such cultural artefacts.

Our results and their interpretation open up analysis of the quasi-pedagogic discourse on mathematics articulated by the advertising industry to a significant problematic, relating to the cultural field and its dynamics. We argue that the use of mathematics, and in particular of simple equations or formulae, is gradually becoming part of an emerging global 'newspeak' (cf. Nóvoa, 2002, p. 135), an indication of the 'technicising' of language (including mathematics with its highly specialised forms), in the service of the market-capitalist order. The increasing presence in the public domain of previously relatively exclusionary languages and knowledges like mathematics – in the form they appear – may undermine their real power as intellectual tools to understand and

lead developments in society. Paradoxically, the meaninglessness and emptiness of mathematical content is 'meaningful': the oversimplified mathematical forms and newspeak become the linguistic structure of global capitalism, addressing, regulating and 'pedagogising' the global consumer community (Bernstein, 2000).

This is perhaps especially apparent in the finding related to that most globalised industry, financial services. Almost half (48.2%) of our adverts were coded as relating to 'Business finance & services' or to 'Personal finance', apparently addressing different fractions of the middle classes. These results support the general impression of there being more 'mathematical' advertising for financial services than for other product types in the UK in recent years, particularly during 2006-2008 (Czarnecka & Evans, 2013).

The aim of advertising is, undoubtedly, to attract instant attention, while invoking only comfortable, taken-for-granted background ideas; it is not their purpose to interest readers in mathematics, nor to provide 'mathematical challenges'. Yet, in a world requiring instant communication practices, mathematics may be recruited for advertising messages, because its economical forms – and relative independence from any particular natural language – can convey quickly the 'message' across the globe. These forms become the communication 'technologies' *par excellence* for contemporary forms of subjectivity (Martin, Gutman & Hutton, 1988): they shape desire, especially for middle class strata that remain (or aspire to be) 'up-market' clients amongst global consumers. While such strategies of appropriation by advertising might hinder the use of mathematics as a critical discourse for citizens, the consequences may be even more damaging for the subject of mathematics itself.

The low level of mathematical demand made on readers by these adverts suggests that both policy makers and researchers need to consider how cultural representations work to undermine or nullify the positive strategies, designed by teachers and other agents, to improve the general level of mathematical knowledge. In particular, we can see how such oversimplified forms of mathematics may lead to confusion among pupils / students who have to acculturate themselves to very specialised meanings; examples of such confusion would be the erroneous answers typically given to the 'Students and Professors problem' (e.g. Leron & Hazzan, 2006). This raises issues of how public discourse can promote, not undermine, educational and societal aims for young people to be valuing, choosing, and learning mathematics.

Thus we suggest caution about using such advertisements as resources in mathematics classrooms. Nonetheless, with appropriate care, some adverts might indeed be useful in teaching. Students could discuss the adverts' effectiveness as adverts – and the mathematical images, including whether they are 'properly mathematical' (Shapiro, 1993, quoted in Appelbaum, 1995, pp. 200-202). Or they might explore how adverts might influence their feelings about mathematics – and also to directly confront issues of 'power and identity politics' (Appelbaum, 1995; Mendick, 2007).

Our quantitative analysis describes the sample of advertisements, and variations across newspapers – and provides a context for the qualitative analysis of particular adverts. The discourse analysis shows how the mathematics is used in particular adverts, and how readers are thereby positioned. Here we show what can be done with mixed methods analysis, especially in the light of our concerns with social difference and social justice (Evans & Tsatsaroni, 2008).

We see further research as important on several levels. First, in the light of the different readings possible of these adverts – and of what is 'mathematical' – we aim to extend this work in two ways: (a) by 'audience research' interviews, gauging reactions to selected adverts, to supplement, rather

than replace, analysis of texts (for some preliminary results, see Evans, 2012); and (b) by interviews with advertising practitioners, to elucidate the 'context of production' of such adverts (Lister & Wells, 2001). Second, other media fields can be investigated for their images of mathematics (cf. Mendick, 2007). Third, our work suggests ways that similar studies of the prevalence of mathematical images in other cultures might be carried out, using the sorts of analyses described here.

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References

Appelbaum, P. M. (1995). *Popular culture, educational discourse, and mathematics.* Albany New York: SUNY Press.

Atweh, B., Graven, M., Secada, W., & Valero, P. (Eds.) (2011). *Mapping Equity and Quality in Mathematics Education.* New York: Springer.

Bell, P. (2001). Content analysis of visual images. In T.Van Leeuwen & C. Jewitt (Eds), *Handbook of visual analysis* (pp.10-34). London: Sage.

Bernstein, B. (1990). *Class, Codes and Control, Vol. IV: The Structuring of Pedagogic Discourse*. London: Routledge.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity: theory, research, critique*. New York: Rowman & Littlefield.

Bernstein, B. (2001). Symbolic control: issues of empirical description of agencies and agents. *International Journal of Social Research Methodology*, 4(1), 21-33.

Black, L., Mendick, H. & Solomon, Y. (Eds) (2009). *Mathematical Relationships in Education: Identities and Participation*. London: Routledge.

Blastland, M. & Dilnot, A. (2007). *The Tiger that Isn't: Seeing through a world of Numbers*. London: Profile Books.

Chouliaraki, L. & Fairclough, N. (1999). *Discourse in late modernity. Rethinking critical discourse analysis*. Edinburgh: Edinburgh University Press.

Ciochetto, L. (2011). Advertising and value formation: The power of multinational companies. *Current Sociology, March* (59), 173-185.

Coben, D. (2000). Mathematics or Common Sense? Researching 'Invisible' Mathematics through Adults' Mathematics Life Histories. In D. Coben, J. O'Donoghue & G.E. FitzSimons (Eds), *Perspectives on Adults Learning Mathematics: Research and Practice* (pp.53-66). Dordrecht NL: Kluwer.

Cridland, J. (2009). Newspapers in the UK: An introduction. Retrieved from: http://www.mediauk.com/article/4/newspapers-in-the-uk-an-introduction

Czarnecka, B., & Evans, J. (2013). Wisdom appeals in UK financial services. *Journal of Promotion Management*, 4, x-x (accepted for publication).

Delamont, S. & Atkinson, P. (2007). Basil Bernstein. In J. Scott (Ed.) *Fifty key sociologists: The contemporary theorists* (pp. 35-39). London: Routledge.

Dorling, D. & Simpson, L. (Eds) (1998). *Statistics in Society: the Arithmetic of Politics*. London: Arnold.

Epstein, D., Mendick, H. & Moreau, M.-P. (2010). Imagining the mathematician: young people talking about popular representations of maths. *Discourse: Studies in the Cultural Politics of Education, 3*(1), 45-60.

Evans, J. (2012). Adult Students' Response to Images of Mathematics in Advertising. In T. Maguire & J. Keogh (Eds.), *Proceedings of ALM-18 Tallaght, Dublin, Ireland, June 2011* (pp. 118-128).

Evans, J., Morgan, C. & Tsatsaroni, A. (2006). Discursive positioning and emotion in school mathematics practices. *Affect in Mathematics Education: Exploring Theoretical Frameworks, Educational Studies in Mathematics,* A *PME Special Issue*, 63(2), 209-226.

Evans, J., Tsatsaroni, A. & Staub, N. (2007). Images of Mathematics in Popular Culture / Adults' Lives: a Study of Advertisements in the UK Press. *Adults Learning Mathematics: an International Journal, 2(*2), 33-53.

Evans, J. & Tsatsaroni, A. (2008). Methodologies of research into gender and other social differences within a multi-faceted conception of social justice. *Adults Learning Mathematics International Journal, Special Issue on The Future of Mathematics in Adult Education from Gender Perspectives, 3*(1),13-31.

Fiske, J. (1989). *Understanding Popular Culture*. New York: Routledge.

FitzSimons G. (2002). *What counts as mathematics: Technologies of power in adult and vocational education.* Dordrecht: Kluwer.
Foucault, M. (1977). *Discipline and Punish. The birth of the prison*, transl. Alan Sheridan. London: Penguin Books.
Hall, S. (1980). Encoding and decoding. In S. Hall et al (Eds) *Culture, Media, Language*. London: Hutchinson.
Heath, R.G. & Feldwick, P. (2007). 50 years using the wrong model of TV advertising, *Proceedings of the 50th Market Research Society Conference*, Brighton, March.
Krugman, H.E. (1971). Brain wave measurement of media involvement. *Journal of Advertising Research*, 2(1),3–9.
Leiss, W., Kline, S., & Jhally, S. (1990). *Social communication in advertising: Persons, products and images of well-being*, 2nd edn. London: Routledge.
Leron, U. & Hazzan, O. (2006). The Rationality Debate: Application Of Cognitive Psychology To Mathematics Education. *Educational Studies in Mathematics*, 62, 105-126.
Lister, M. & Wells, L. (2001). Seeing beyond belief: Cultural studies as an approach to analysing the visual. In T. van Leeuwen & C. Jewitt (Eds), *Handbook of visual analysis* (pp.61-91). London: Sage.
Maas, J. & Schloeglmann, W. (Eds.) (2009). *Beliefs and Attitudes in Mathematics Education: New Research Results*. Rotterdam: Sense Publishers.
Martin, L. H., Gutman, H. & Hutton, P. H. (Eds.) (1988). *Technologies of the self: a seminar with Michel Foucault*. Amherst MA: University of Massachusetts Press, 1988.
McCracken, G. (1986). Culture and consumption: a theoretical account of the structure and movement of the cultural meaning of consumer goods. *Journal of Consumer Research*, 13(1),71-84.
Mendick, H. (2007). *Mathematical images and identities: education, entertainment, social justice: Full Research Report*, ESRC End of Award Report, RES-000-23-1454. Swindon: ESRC. Retrieved from: http://www.esrc.ac.uk/my-esrc/grants/RES-000-23-1454/outputs/Read/1a89a4ee-7d3a-45be-bbb1-4d9f8617f2a2.
Moore, R. with Jones, L. (2007). Appropriating competences: the competency movement – The New Right and the 'culture change' project. In R. Moore, *Sociology of knowledge and education*. London: Continuum.
NCTM (National Council of Teachers of Mathematics) (1989). *Curriculum and Evaluation Standards for School Mathematics.* Reston VA: NCTM.
Newspaper Marketing Agency (2012). *Newspaper data.* Retrieved from: http://www.nmauk.co.uk/nma/do/live/factsAndFigures
Noss, R. (1997). *New Cultures, New Numeracies: an Inaugural Lecture*. London: Institute of Education.
Nóvoa, A. (2002). Ways of thinking about education in Europe. In A. Nóvoa, & M. Lawn, (Eds) (2002) *Fabricating Europe. The Formation of an Education Space* (pp.131-155). Dordrecht NL: Kluwer.
NRS (2006-07) *National Readership Survey, October 06 – September 07*. Retrieved from: http://www.nrs.co.uk/top_line_readership.
Rizvi, F. & Lingard, B. (2010). *Globalizing education policy*. Abingdon: Routledge.
Rose, G. (2007). Visual *Methodologies: An Introduction to the Interpretation of Visual Materials*, 2nd edn. London: Sage.
Sarakinioti, A., Tsatsaroni, A. & Stamelos, G. (2011). Changing knowledge in higher education. In G. Ivinson, B. Davies & J. Fitz (Eds.), *Knowledge and Identity: Concepts and applications in Bernstein's Sociology* (pp. 69-89). London & New York: Routledge.
Van Leeuwen, T. (2001). Semiotics and iconography. In van Leeuwen, T. & Jewitt, C. (Eds.) (2001). *Handbook of Visual Analysis* (pp.92-118). London: Sage.

Van Leeuwen, T. & Jewitt, C. (Eds.) (2001). *Handbook of Visual Analysis*. London: Sage.
Wells, W., Moriarty, S. & Burnett, J. (2006). *Advertising, Principles and Practice*. London: Pearson.
Williamson, J. (1978). *Decoding Advertisements*. London: Marion Boyars.

Tables and Figures

Table 1. Incidence of advertisements containing 'mathematical images' by newspaper (n=76)

Newspaper and type[14]	No. of adverts	No. of editions	Incidence
Financial Times (Q)	24	182	13.1%
The Times (Q)	16	182	7.3%
Daily Telegraph (Q)	9	152	5.9%
The Guardian (Q)	16	274	5.8%
Daily Express (M)	4	172	2.3%
Daily Mail (M)	4	172	2.3%
Daily Mirror (P)	2	152	1.3%
Daily Star (P)	1	157	0.6%
The Sun (P)	0	166	0.0%
Total	**76**	**1609**	**4.7%**

Table 2. Incidence of 'mathematical advertisements' by gender and social class of newspaper readership[15]

Newspaper	% Male readers	% ABC1 readers	Incidence
Financial Times	74.1	94.1	13.1%
The Times	58.2	89.0	7.3%
Daily Telegraph	55.7	86.0	5.9%
The Guardian	55.7	91.7	5.8%
Daily Express	51.3	60.8	2.3%
Daily Mail	47.8	65.4	2.3%
Daily Mirror	52.8	41.9	1.3%
Daily Star	70.5	32.0	0.6%
The Sun	56.8	36.8	0.0%
Total			**4.7%**

Table 3. Incidence of advertisements including 'mathematical images' by newspaper type

Publication type	No. of adverts	No. of editions	Incidence
Quality	65	790	8.2%
Mid-market	8	344	2.3%
Popular	3	475	0.6%
Total	**76**	**1609**	**4.7%**

[14] Q = 'Quality' newspaper; M = Mid-market newspaper; P = 'Popular' newspaper.

[15] Readership data from the *National Readership Survey Oct.2006-Sep.2007* (NRS, 2006-07)

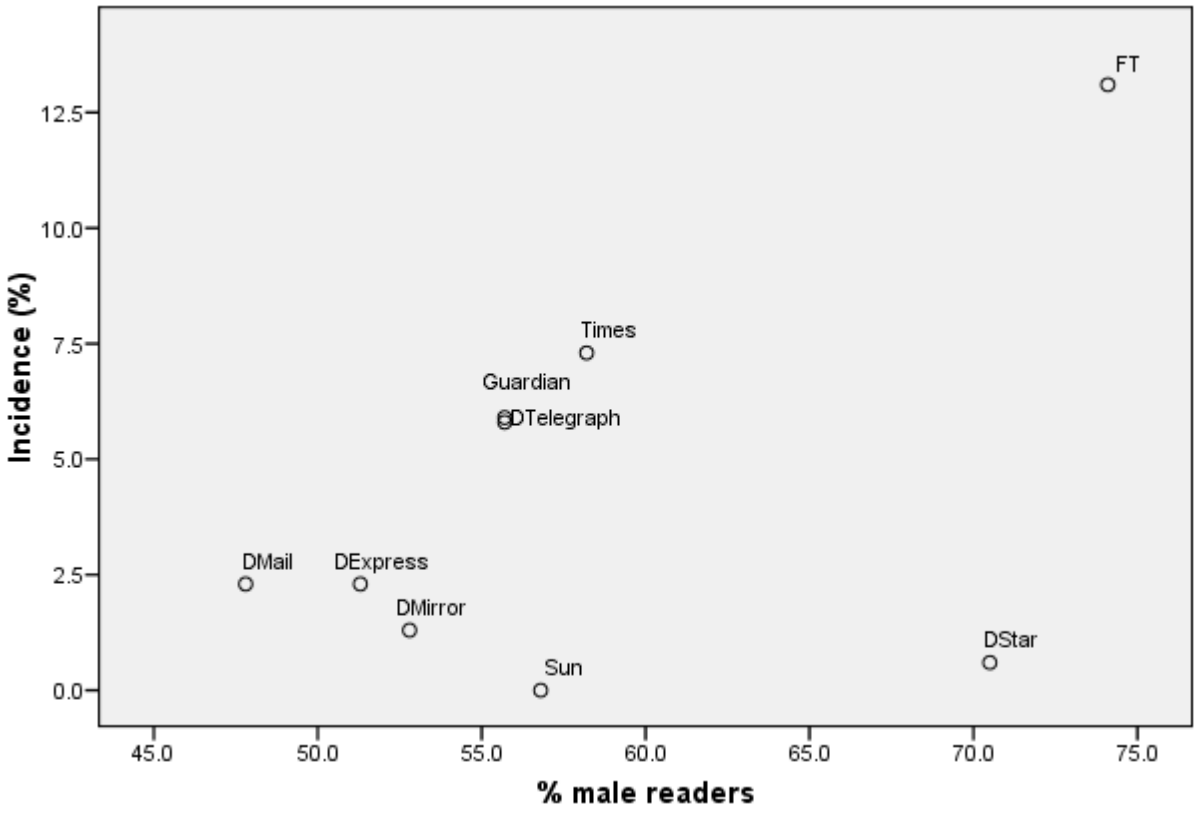
Table 4. Type of mathematical content in image used (n = 56 distinct advertisements)

Type of Mathematical Content	**No. of adverts**	**Percent**
Keywords	8	14.3
Name or picture of mathematician	0	0.0
Configuration of numbers, measurements, or mathematical symbols	7	12.5
Squares, powers etc.	8	14.3
Charts, graphs	17	30.4
Equations, formulae	16	28.6
Total	**56**	**100**

Table 5. Crosstabulation of complexity of mathematical content by type of newspaper

Newspaper type		**Popular**	**Mid-market**	**Quality**	**Total**
Complexity of Mathematical Content	**Simple**	2.5 (100%)	4 (88.9%)	34.5 (70.4%)	41 (73.2%)
	More advanced	0 (0.0%)	0.5 (11.1%)	14.5 (29.6%)	15 (26.8%)
Total		**2.5 (100%)**	**4.5 (100%)**	**49 (100%)**	**56 (100%)**

Fig. 1 Scatterplot of percentage of male readers with incidence of mathematical images, by newspaper (n = 9)



Note: The two points that are almost coincident refer to the *Daily Telegraph* and the *Guardian*.

Fig. 2 '40 min + £199 = Your Perfect Mortgage' (Charcol direct, *The Times*, Nov. 2006)

Fig. 3 ‘Give him the Lift Off Rocket and who knows what he’ll grow up to be’ (Early Learning Centre, *The Times* and *Daily Mail*, Nov. 2006)

Fig. 4 'Innovative Financial Solutions' (Northern Trust, *Financial Times* , March 2008)